C

Convergent Evolution of Intelligence Between Corvids and Primates

Danielle Sulikowski
Perception and Performance Research Group, School of Psychology, Charles Sturt University, Bathurst, NSW, Australia

Synonyms

Cognitive ornithology; Cognitive primatology; Comparative cognition in corvids and primates; Evolution of intelligence

Definition

Convergent evolution describes the analogous (as opposed to homologous) acquisition of similar traits in phylogenetically diverse species facing similar selection pressures. Corvids and primates are often observed to exhibit highly intelligent behavior (with intelligence typically operationalized in this context as those behaviors that indicate the presence of advanced capacities once thought unique to humans or cognitive capacities which surpass those of humans). This led Emery and Clayton (2004) to identify primates and corvids as a case of convergent evolution of intelligence, citing the two groups' capacity for causal reasoning, cognitive flexibility, imagination, and prospection as the key ingredients of a shared cognitive toolkit.

Introduction

Primates and corvids comprise some of the most enigmatic study species in the field of comparative cognition. These two groups have produced some of the strongest claims of advanced intelligence among non-human animals. Wolfgang Köhler's *The Mentality of Apes* (1925) argued for a level of intelligence in apes that was primitive relative to that seen in humans but nevertheless sufficiently advanced as to justify the term *intelligent,* an adjective not afforded to any other non-human animal at the time. Nearly 100 hundred years later, Emery and Clayton (2004) published *The Mentality of Crows: Convergent Evolution of Intelligence in Corvids and Apes,* a clear reference to Köhler's seminal work. They observed the large brains (relative to body size) of both groups and argued that the cognitive feats observed in corvids were comparable to those previously celebrated in apes as indicative of advanced intelligence.

What Is Advanced Intelligence?

What constitutes advanced intelligence is a controversial and complex issue (Sulikowski and Burke 2015). Episodic memory, theory of mind,

T. K. Shackelford, V. A. Weekes-Shackelford (eds.), *Encyclopedia of Evolutionary Psychological Science*,
https://doi.org/10.1007/978-3-319-16999-6_3107-1

planning, and tool manufacture have all been nominated as feats of advanced intelligence. It is no coincidence that these same abilities are also those that have been indicated (at one point in time) as uniquely human traits. Reports of such advanced cognitive feats in non-human animals (such as the examples cited below) are thus frequently framed as breaking down the discontinuities between abilities (once) thought to be uniquely human and the cognitive abilities of animals more broadly. This anthropocentric perspective of what constitutes advanced intelligence derives from the study of intelligence in primates (described below).

When they first suggested that corvids and apes constituted a case of convergent evolution of intelligence, Emery and Clayton (2004) highlighted examples of corvid cognition from these categories to demonstrate that corvids exhibited cognitive feats comparable to those seen in apes. They also referred to examples of transitive inference (being able to conclude that A is larger than C, based on knowledge that A is larger than B and B is larger than C) and the extensive spatial memory required to support cache recovery. They argued that four "cognitive tools," present in both apes and corvids, were necessary and sufficient to support the evolution and development of such complex cognition:

- *Causal reasoning* (this includes reasoning about the physical causes of object-object interaction outcomes, such as occurs during tool use, and also to reasoning about the intentions and motivations of others, necessitating an attribution of agency to others)
- *Flexibility* (the ability to act on information flexibly by generalizing rules learned in one scenario to a novel circumstance or object)
- *Imagination* (the capacity to mentally perceive objects and stimuli that are not currently available to the senses, it would permit contemplation of problems not immediately present and may also support functions like cognitive maps, which require an integrated knowledge of disparate locations which are never simultaneously present)
- *Prospection* (somewhat related to imagination and potentially arising out of it, prospection describes the specific simulation of future events, permitting an individual to act purposefully in accord with future, rather than current, needs and motivations)

Therefore, intelligence in this instance is most appropriately operationalized as the cognitive feats (episodic memory, theory of mind, planning, tool manufacture, transitive inference) that provide evidence of Emery and Clayton's cognitive tools (causal reasoning, flexibility, imagination, and prospection).

Intelligence in Primates

The study of intelligence in primates has unavoidably anthropocentric roots. Much research on the cognitive capacities of primates focuses on the comparison between what humans do and what primates can achieve. Against the backdrop of an early twentieth-century presumption of a unique and superior human intellect that was qualitatively unlike that seen in any non-human animal, Koehler's (1925) work was the first to suggest that another animal, the chimpanzee, may possess a mind capable of the flexibility, creativity, and insight (that was) intuitively recognized as intelligent (albeit not necessarily to the extent seen in man). Much latter-half twentieth-century primate cognition research was guided by a tacit agenda to deconstruct the notion of human uniqueness by closing the cognitive gap between humans and great apes (discussed in Povinelli and Bering (2002)). This was achieved via demonstrations in chimpanzees (and other primates), of cognitive abilities previously presumed to be unique to humans, including theory of mind (the capacity to appreciate that other individuals experience their own perceptions and goals that are independent of your own, reviewed by Call and Tomasello (2008)) and causal reasoning about the physical properties of objects (primarily as pertaining to tool use, reviewed by Call (2010)).

Intelligence in Corvids

Studies of corvid cognition rose to prominence much later in the twentieth century. They appeared against a backdrop of theoretical focus on ecologically adaptive specializations of cognition. Not anthropocentrically motivated, hypotheses were derived and tested based on the selection pressures species were presumed to face. In corvids, initial investigations focused on cognitive adaptations that may have arisen to support foraging. Clark's nutcrackers recover tens of thousands of seeds, months after caching (necessitating exceptional spatial memory), and New Caledonian crows manufacture specialized hook twig tools and stepped-cut leaf tools to retrieve prey from holes and crevices, implying a causal understanding of the physical effects of the tools (reviewed in Taylor (2014)).

Observations of tool manufacture and use, in particular, invited comparisons between primate and corvid intelligence (Emery and Clayton 2004; Lefebvre et al. 2004). This motivated further investigations of corvid cognition, focused on demonstrating the nominally intelligent behaviors to date observed only in humans and non-human primates. Subsequent evidence of episodic memory (termed episodic-like memory when observed in non-human animals, since episodic memory itself is a term reserved for human cognition and implies a subjective experience not necessarily observable in non-human animals, reviewed in Salwiczek et al. (2010)), planning (Raby et al. 2007), and theory of mind (reviewed in Taylor (2014)) emerged.

Selection Pressures Leading to Advanced Intelligence in Primates and Corvids

Two broad theories have been put forward to account for the advanced intelligence reported in apes and corvids. The first identifies ecological selection pressures (especially those derived from tool use and manufacture to support innovative foraging behaviors) as the primary drivers behind both larger brains and advanced intelligence (Lefebvre et al. 2004). Within both primates and birds (including but not restricted to corvids), innovative foraging behaviors predict larger brains (especially areas in the forebrain associated with higher-order integration of information) and greater propensity for tool use (Lefebvre et al. 2004). The need to innovate new foraging behavior and to create novel tools could create selection pressure for all four of Emery and Clayton's (2004) cognitive tools to emerge. Flexibility of behavior and prospection (foreseeing the consequences of novel actions) would both promote innovation. Causal reasoning (about the interactions between physical objects) and imagination (to support the insight required to use or fashion novel objects into tools) were argued by Clayton and Emery to be critical to the evolution of tool manufacture and use. Relationships between innovation, brain size, and tool use within other (non-corvid) avian clades suggest that the potential convergent evolution Emery and Clayton described between corvids and primates may extend to other larger-brained and innovative avian species (including parrots and woodpeckers).

The second theory, known as the social intelligence hypothesis, identifies selection pressures derived from complex social interactions as the key driving force (Holekamp 2007). While social complexity predicts brain size and innovation well in primates, the same is not true for corvids (or birds more generally; Holekamp 2007). As such the applicability of the social intelligence hypothesis to corvids may be limited. Observations of hyenas, who live in complex hierarchically structured social systems, have relatively larger brains than other less socially complex carnivores, and use transitive inference to deduce social ranks of conspecifics, suggest that, within mammals, the social intelligence hypothesis may apply outside primates as well (Holekamp 2007).

These theories ought not to be considered as necessarily mutually exclusive. It is possible, even likely, that selection pressures derived from multiple sources have acted on the brains and cognition of both crows and primates to convergently produce advanced intelligence in these groups. Social complexity may have played a less prominent role in brain enlargement in corvids than in primates; corvids (western scrub jays) nevertheless exhibit evidence of advanced social cognition, in the form of theory of mind (reviewed in Taylor (2014)). As such, the relative contribution of selection pressures derived from social and nonsocial complexity may differ between primates and corvids, but the resulting advanced intelligence manifests comparable ways.

Conclusion

Claims of convergent evolution of intelligence in corvids and primates rest primarily on demonstrations of cognitive feats in both groups that meet intuitive (and somewhat traditional and anthropocentric) notions of advanced intelligence. These include demonstrations of planning, theory of mind, tool manufacture and use, and episodic memory – all skills once considered unique to humans. Emery and Clayton (2004) proposed that these skills are supported by four cognitive tools (causal reasoning, flexibility, imagination, and prospection), which evolved convergently in corvids and primates. Selection pressures that may have led to these tools include those derived from innovative foraging behavior (especially that involving tools) and from the cognitive complexities involved in navigating social interactions within a large group of conspecifics. Broader comparisons, across other avian and mammalian groups and species, lend support to both possibilities and suggest that the convergent evolution of intelligence observed in corvids and apes may extend to other large-brained, innovative, and social groups of species.

Cross-References

- ► Bird Tool Use
- ► Causal Reasoning
- ► Convergent Evolution of Hyena and Primate Social Systems
- ► Convergent Evolution of Intelligence
- ► Corvids
- ► Non-Human Primates
- ► Non-Human Tool Use
- ► Primate Tool Use
- ► The Social Intelligence Hypothesis

References

Call, J. (2010). Trapping the minds of apes: Causal knowledge and inferential reasoning about object–object interactions. In E. V. Lonsdorf, S. R. Ross, & T. Matsuzawa (Eds.), *The mind of the chimpanzee: Ecological and experimental perspectives*. Chicago: University of Chicago Press.

Call, J., & Tomasello, M. (2008). Does the chimpanzee have a theory of mind? 30 years later. *Trends in Cognitive Sciences, 12*, 187–192.

Emery, N. J., & Clayton, N. S. (2004). The mentality of crows: Convergent evolution of intelligence in corvids and apes. *Science, 306*, 1903–1907.

Holekamp, K. E. (2007). Questioning the social intelligence hypothesis. *Trends in Cognitive Sciences, 11*, 65–69.

Köhler, W. (1925). *The mentality of apes*. London: Kegan Paul, Trench, Trubner. Translation of: Köhler, W. (1917). *Intelligenzprüfungen an Anthropoiden* (trans: Winter, E.). Berlin: Royal Prussian Society of Sciences.

Lefebvre, L., Reader, S. M., & Sol, D. (2004). Brains, innovations and evolution in birds and primates. *Brain, Behavior and Evolution, 63*, 233–246.

Povinelli, D. J., & Bering, J. M. (2002). The Mentality of Apes revisited. *Current Directions in Psychological Science, 11*, 115–119.

Raby, C. R., Alexis, D. M., Dickinson, A., & Clayton, N. S. (2007). Planning for the future by western scrub-jays. *Nature, 445*, 919.

Salwiczek, L. H., Watanabe, A., & Clayton, N. S. (2010). Ten years of research into avian models of episodic-like memory and its implications for developmental and comparative cognition. *Behavioural Brain Research, 215*, 221–234.

Sulikowski, D., & Burke, D. (2015). From the lab to the world: The paradigmatic assumption and the functional cognition of avian foraging. *Current Zoology, 61*, 328–340.

Taylor, A. H. (2014). Corvid cognition. *Wiley Interdisciplinary Reviews: Cognitive Science, 5*, 361–372.